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Author: Mr. senthilkumar subramanian
University of Glasgow, United Kingdom

Mr. Andrew Wilson
University of Glasgow, United Kingdom
Dr. Craig White
University of Glasgow, United Kingdom
Prof. Konstantinos Kontis
University of Glasgow, United Kingdom
Dr. David Evans
Fluid Gravity Engineering Ltd, United Kingdom
Dr. Jeroen Van den Eynde
ESTEC, European Space Agency, The Netherlands

EXPERIMENT ON PLUME REGOLITH INTERACTION IN MARTIAN ATMOSPHERIC CONDITIONS

Abstract

During the final landing phase of a powered descent to Mars, the rocket exhaust impacting the surface disturbs the surface regolith material. In addition, the reduced gravity and thin atmosphere on Mars do not slow down particles as effectively as they do on Earth. Because of this, they stay afloat longer and can travel faster and further than on Earth. This poses dangers for the lander equipment (sensors, solar panels, antennas, etc) and the cloud of dust may disrupt radio and radar systems during the final moments. Hence, understanding the effect of rocket plume-regolith interaction in Martian environments is critical in the context of future Martian landing missions.

The present study simulates the Martian landing event in a specialized large-volume plume regolith facility at the University of Glasgow to investigate the plume-regolith interaction at a fundamental level. At 600 Pa background pressure, the tests were representative of the Martian surface atmospheric pressure. The addition of a 70 m^3 buffer tank to the 12 m^3 test chamber allows the background pressure to remain within an acceptable range for a steady nozzle operation of 2.5 seconds. A 45 cm diameter tray filled with dried and crushed walnut shells represents the Martian surface regolith via dynamic scaling. A scaled lander nozzle fixed at 4 nozzle exit diameter vertical distance from the regolith bed produces supersonic flow with an exit Mach number of 5.8. To attain Reynolds number similitude with a full-scale nozzle, the working gas is heated to 700 K. The supersonic plume impinging on the regolith bed liberates the particles, thereby recreating a landing event.

To track the ejected particles, the current investigation used a particle tracking method employing a high-speed laser synchronised with a high-speed camera. Fast tracking technology effectively captured the released particles in the initial moments of plume contact. Inclined crater walls can be observed at the end of the experiment. The direction of the ejected particle vectors evolves, indicating that the released particles exhibit transient and variable behaviour under high-pressure plume impingement. Over time, a rise in the ejection angle from 10 degrees to as high as 40 degrees may be seen. To illustrate the particle ejection angle's transitory character, the particle vectors have been plotted at different spatial positions. Depending on the dimensions of the lander base, the high-speed ejected particles may impinge and can cause damage to the lander components.